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Request for grant of a patent
(See notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office
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1.	Your reference	PHGB 030076GBQ 14 MAY 2003
2.	Patent application number *(The Patent Office will fill in this part)*	0311077.2 14MAY03 E807258-1 D02879 P01/7700 0.00-0311077.2
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	KONINKLIJKE PHILIPS ELECTRONICS N.V. GROENEWOUDSEWEG 1 5621 BA EINDHOVEN THE NETHERLANDS
	Patents ADP Number *(if you know it)*	07419294001
	If the applicant is a corporate body, give the country/state of its incorporation	THE NETHERLANDS
4.	Title of the invention	IMPROVEMENTS IN OR RELATING TO WIRELESS TERMINALS
5.	Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Philips Intellectual Property and Standards Cross Oak Lane Redhill Surrey RH1 5HA
	Patents ADP number *(if you know it)*	08359655001
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country / Priority Application number *(if you know it)* / Date of filing *(day/month/year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application / Date of filing *(day/month/year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer "Yes" if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

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9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document.

Continuation sheets of this form	
Description	5
Claims(s)	0
Abstract	0
Drawings	3

10. If you are also filing any of the following, state how many against each item:

Priority Documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)	
Request for preliminary examination and search (*Patents Form 9/77*)	
Request for substantive examination (*Patents Form 10/77*)	
Any other documents (*Please specify*)	

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 14/5/2003

12. Name and daytime telephone number of person to contact in the United Kingdom 01293 815438 (A. G. WHITE)

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Notes

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DESCRIPTION

IMPROVEMENTS IN OR RELATING TO WIRELESS TERMINALS

Introduction

The present invention relates to a method of reducing the volume of a multi-band antenna structure by combining the properties of Planar Inverted-F Antennas (PIFA's) and notches, and also to an antenna structure and wireless terminal featuring the same. The main application is cellular telephony.

State of the Art (a.)

PIFA antennas are popular in mobile phones (Nokia use them almost exclusively, for example). The principal reasons for this are that:

- they exhibit low SAR performance (and less loss to the head)
- they are installed above the phone circuitry and, therefore, "re-use" the space within the phone to some degree

However, such antennas are physically large and are difficult to use over more than two cellular bands. The best performing antennas are capable of operation at GSM, DCS and PCS.

The Problem (b.)

To reduce the antenna volume or increase the number of bands covered. Clearly there is a trade off between these two aims.

The Measures Proposed (c.)

To use the PIFA predominantly for transmission, since SAR is only relevant in this mode. To use a co-located notch for reception (or when SAR is not considered to be important).

The European and North American cellular bands are shown in Figure 1. The transmit bands are shown in dark grey (to the left of each pair), while the receive bands are shown in light grey (to the right). In Europe both the GSM

and DCS bands accommodate time division duplex systems, while the UMTS bands are predominantly frequency division, full duplex. In the USA, a mix of systems and duplex methods are used in the AMPS and PCS bands. The advanced wireless systems (AWS) bands have recently been allocated for 3G systems, though it has yet to be resolved how the bands will be used.

A principal feature of the present invention is to use notches for the receive bands and a PIFA or PIFAs for the transmit bands. When the PIFA is used the notch can be de-activated by switching across its open end. Since PIFAs and notches can occupy the same volume, and both antennas are required to cover only a sub-section of the total bandwidth, the total volume occupied can be reduced.

Embodiments (d.)

GSM/DCS/PCS/Bluetooth Configuration

Currently many phones are being made to support the European GSM and DCS bands together with the US PCS bands (in the TDMA IS54/136 mode). Since many other countries have adopted either the European or US band allocations, this allows near-worldwide roaming. To cover these bands an antenna fractional bandwidth of 15.1% is required (1710–1990HMz). To cover the transmit bands only, a fractional bandwidth of only 11% is required – i.e., the required bandwidth is reduced by approximately one third. To take advantage of this, the PCS RX band can be implemented as a notch.

This is illustrated in Figure 2. Here a notch N is implemented in the PCB below a dual-band GSM/DCS PIFA. The notch is fed near its closed end and tuning/switching is applied at the open end.

With a small tuning capacitor at the open end, the notch can be used for Bluetooth, or any other frequency in the ISM band in the region of 2.4GHz (this varies from country to country), without adversely affecting the performance of the dual-band PIFA.

With a larger tuning capacitor, the notch can be used for the PCS receive band (from 1930-1990MHz). Since this frequency is close to the upper frequency at which the PIFA operates, it is necessary to short circuit the notch at the open end when the PIFA is in use. This can be achieved via a simple switch (for example a PIN diode, FET or MEMs device).

With the switch ON, the S_{11} performance of the dual-band PIFA on a 40x100x1mm PCB is as shown in Figure 3 (markers s1 and s2 show the GSM band edges while markers s3 and s4 show the DCS band edges). It can be seen that the notch has no effect on the input impedance of the PIFA. It is expected that the notch will also not adversely affect the SAR.

In the simulation above the total efficiency of the antenna (including mismatch) is greater than 60% over the GSM and DCS bands, despite the fact that the switch is assumed to have on ON resistance of just 10Ω. Hence it is demonstrated that, in the ON condition, the switch quality is not an important factor.

With the switch OFF and an optimal tuning capacitance applied at the open end off the notch, the S_{11} performance of the notch is as shown in Figure 4 (markers s1 and s2 show the PCS RX band edges). Here the OFF state is assumed to be provided by a PIN diode with a reverse bias capacitance of 0.2pF and a Q of 20. Under such conditions a worst-case efficiency (including mismatch) of 50% is achieved. Better performance could be achieved with the use of better quality switches, such as MEMs devices etc.

Figure 5 schematically represents the above circuit model for the PIFA and notch.

The notch can also be de-activated using passive filtering. For example, a PIFA may be used for UMTS TX while a notch is used for UMTS RX. Since both TX and RX are simultaneously required for UMTS, the notch can be

made to look inactive at the UMTS transmit frequency using a passive network at the open end of the notch. Such a network is required to be substantially open circuit at the RX frequency and substantially short circuit at the TX frequency. This could be achieved with bulk acoustic wave resonators, for example.

More than one notch may be used – for example, for the simultaneous provision of GSM/DCS/PCS and Bluetooth or for the provision of diversity.

Fields of Application (e.)

Any multi-band system where low SAR is only required for some of the bands. Particularly appropriate for all current and future wireless communication systems.

Although the present invention has been described with reference to a wireless terminal having a PIFA antenna and operating in the GSM, DCS and PCS bands. The invention may be applied to any multiband radio and in other dual band applications. Also the present invention relates to an RF module having an antenna and at least those components included in the coupling stages 26A and 26B.

In the present specification and claims the word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. Further, the word "comprising" does not exclude the presence of other elements or steps than those listed.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of wireless terminals and component parts therefor and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation

thereof, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of such features during the prosecution of the present application or of any further application derived therefrom.

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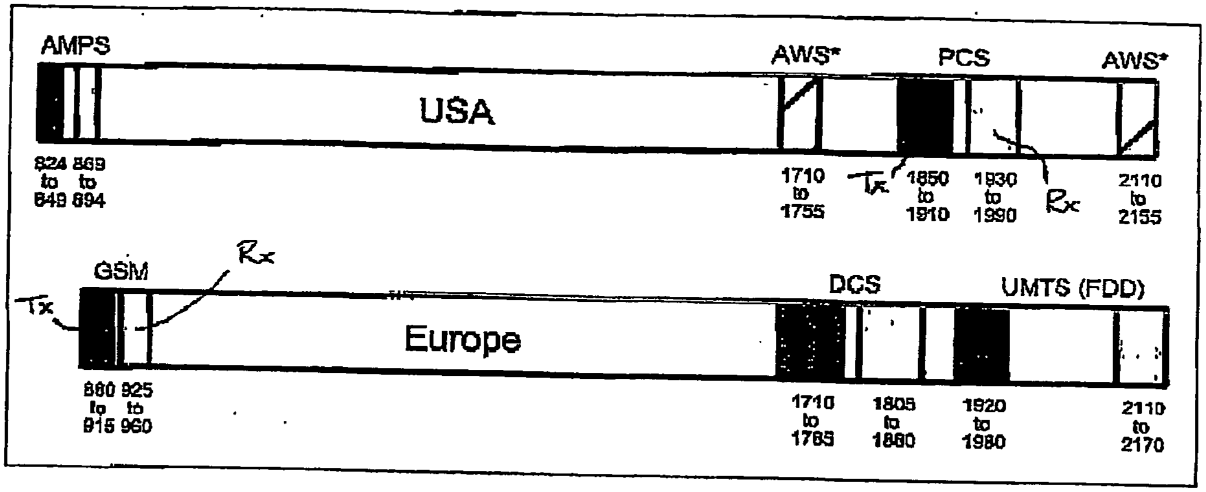

Figure 1 Cellular 2G and 3G Frequency Bands

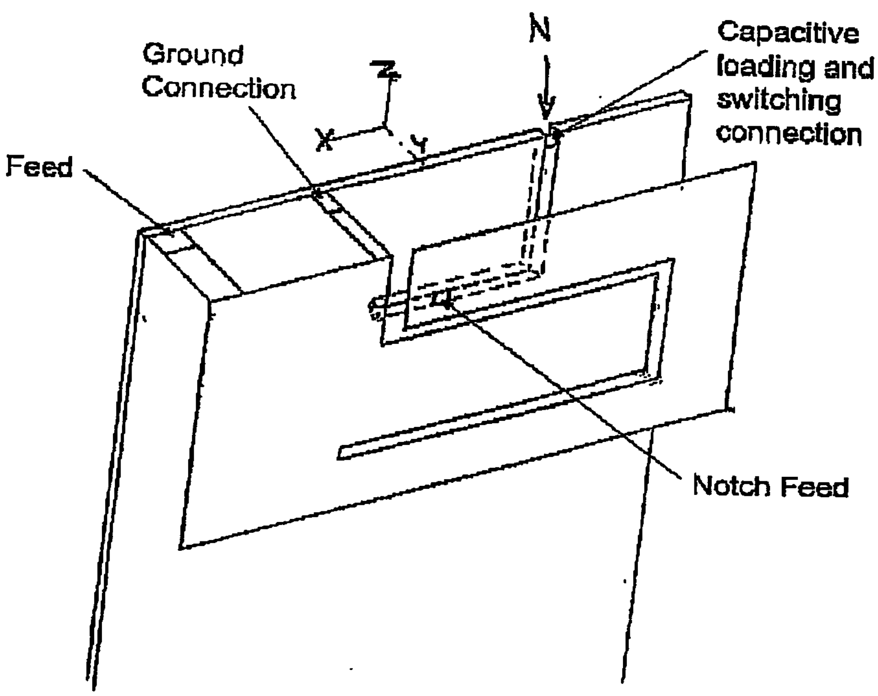

Figure 2 Co-located PIFA and Notch

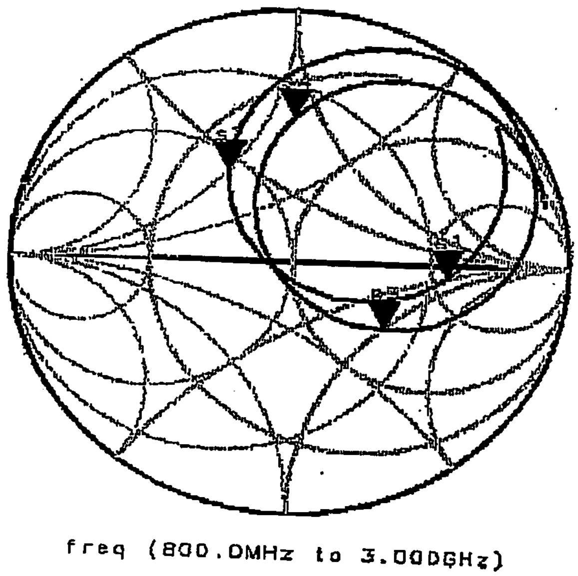

Figure 3 PIFA S_{11}

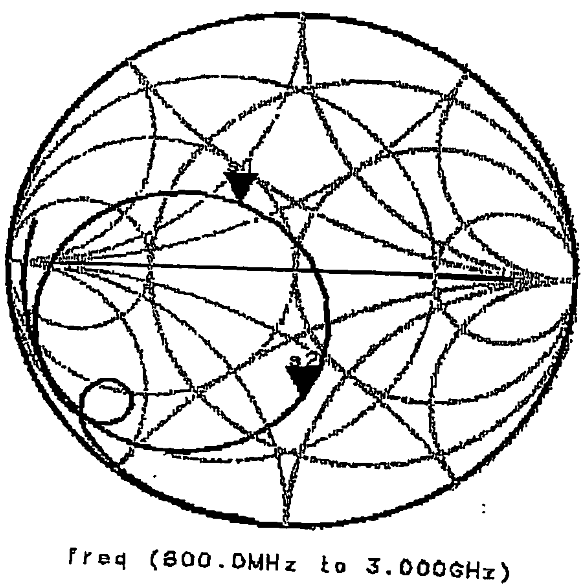

Figure 4 Notch S_{11}

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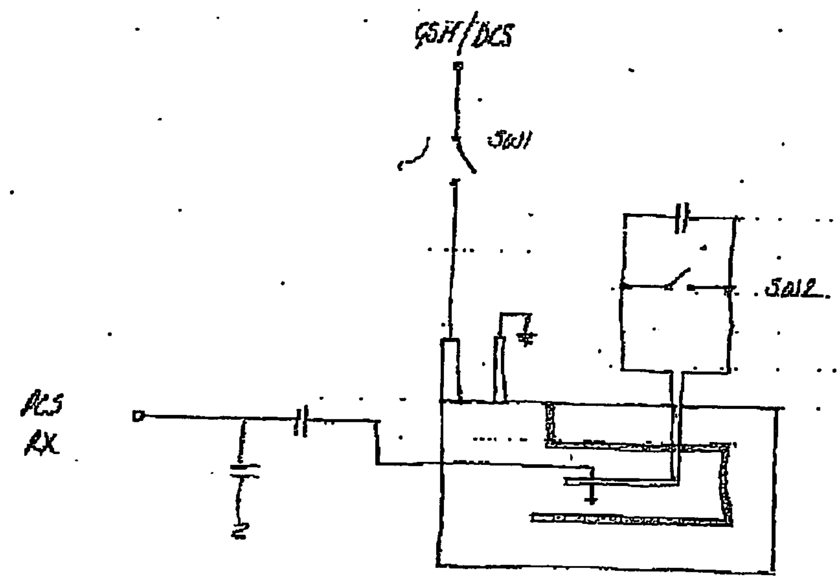

Figure 5 Combined antenna circuit model